Title: Workpiece Cooling during Grinding

Field of Invention

This invention concerns methods and apparatus for grinding, especially grinding the edges of glass plates, and in particular cooling the glass and grinding wheel during the grinding process.

Background to the Invention

It is known to apply water based liquids or coolants to the grinding region between wheel and workpiece during grinding, However such liquids have a disadvantage in that the water content has been found to mark or stain the surface of some workpiece materials, particularly glass components, around the grinding area, particularly the unground regions of component surfaces, which should remain clean. Such marking can be difficult to remove.

It is an object of the present invention to provide a method of cooling and a coolant, apparatus for delivering same during grinding, which will not mark or stain unground workpiece surfaces and is especially applicable to the grinding of glass components, and a grinding machine for performing the method of cooling while grinding without marking or staining the unground workpiece surfaces.

Summary of the Invention

According to one aspect of the invention there is provided a method of cooling during grinding in which liquid nitrogen is applied to the contact region between wheel and workpiece for the purpose of cooling the wheel and workpiece without marking or staining unground regions of the workpiece surface by contact with the coolant.

According to another aspect of the invention there is provided apparatus for supplying liquid nitrogen as a coolant for carrying away heat during the grinding of a workpiece by a rotating grinding wheel to enable a workpiece to be ground and the wheel and workpiece to be cooled during the grinding process without marking or staining unground regions of the workpiece surface by contact with the coolant.

The invention is of particular application to the grinding of flat or profiled surfaces or the edge of glass workpieces in which the liquid nitrogen is directed towards the surface or edge of the glass, or the wheel, or into the nip between the workpiece and the rotating grinding wheel. The absence of a water based coolant in the grinding region reduces the risk of marking or staining of unground surfaces of the workpiece/component which can occur when such liquids are employed.

The invention also lies in a grinding machine when fitted with such apparatus for the aforesaid purpose.

Thus the invention lies in a grinding machine by which a workpiece is ground by engagement with a rotating grinding wheel, comprising a workpiece support, a grinding wheel, drive means therefor, and a wheelhead and drive for moving the wheelhead and therefore the wheel relative to the workpiece, a source of liquid nitrogen under pressure, valve means for controlling the supply of liquid nitrogen therefrom to nozzle means, and adjustable support means adapted to position the nozzle means in the vicinity of the grinding wheel so as in use, when the valve means is open, to direct liquid nitrogen towards the wheel or the workpiece or directly towards the point of contact between the wheel and workpiece, to reduce the heat generated by the grinding engagement of the wheel and workpiece.

Where the workpiece is to be moved relative to the wheel, such as rotated, during grinding, the machine also includes drive means for moving or rotating the workpiece support to progressively present different parts of the surface for grinding.

Preferably further drive means is provided for positioning the nozzle means relative to the workpiece and the wheel, to enable the nozzle to follow any movement of the point of contact between wheel and workpiece during grinding.

Preferably the apparatus or grinding machine includes a computer based control system which is programmed to open valve means to deliver liquid nitrogen coolant to the nozzle when the wheel is rotating and is in grinding contact with the workpiece, and to stop the delivery of the coolant when the wheel and workpiece are disengaged after grinding is completed.

One embodiment of the invention comprises:-

1) a machine bed,
2) a workpiece holder,
3) workpiece drive means for moving the workpiece holder and a workpiece carried thereon,
4) a grinding wheel,
5) a drive by which the grinding wheel is rotated,
6) a wheelhead carrying the wheel and drive therefor,
7) a slideway by which the wheelhead can move relative to the workpiece,
8) a drive for moving the wheelhead,
9) a source of liquid nitrogen,
10) valve means and pipeline means communicating between the source and a nozzle,
11) drive means for positioning the nozzle relative to the wheel and workpiece, and
12) a control system for controlling the operation of each of the drive means and the valve means to supply liquid nitrogen to the grinding region during grinding and to control the nozzle drive means during grinding so as to move the nozzle to direct liquid nitrogen towards the region of grinding contact between the wheel and workpiece.

Preferably the source is a pressure vessel and pressure sensing means is provided for generating a warning signal if the pressure in the vessel drops below a predetermined pressure.

Preferably the predetermined pressure is selected such that there is sufficient liquid nitrogen remaining in the vessel at that pressure, as to ensure that the grinding of a workpiece can be completed before the source is exhausted.

Preferably an interlock is provided to prevent resumption of grinding unless the source is replaced or replenished.

Preferably the control system controls the operation of the rotational drive and/or work support drive and /or the drive for rotating the wheel and/or the wheelhead drive means.

Preferably the control system also controls the operation of the further drive means so as to adjust the position of the nozzle during grinding so as to follow the movement of the wheel relative to the workpiece during the grinding.

The valve means may include pressure reducing means.

Preferably the workpiece is a plate-like component and the workpiece support positions the component so that the edge thereof is presented to the grinding wheel for grinding.

Alternatively the workpiece has a flat or profiled surface which is to be surface ground, and the workpiece support positions the workpiece so that the surface is generally horizontal and parallel to the X-axis of the machine.

In all cases the workpiece is typically formed from glass.

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Fig 1 is a diagrammatic view of a grinding region cooled by liquid nitrogen,

Fig 2 is a diagrammatic view of a surface grinding machine incorporating liquid nitrogen cooling, and

Fig 3 is a diagrammatic view of an edge grinding machine incorporating liquid nitrogen cooling.

In Fig 1 a rotating grinding wheel 10 is shown engaging a flat upper surface or upper edge of a workpiece 12 and a nozzle 14 directing liquid nitrogen 16 towards the grinding region nip between wheel and workpiece. Flow of liquid nitrogen coolant is controlled by a valve 18.

In Fig 2 the wheel 10 workpiece 12 and other apparatus of Fig 1 are shown mounted to a machine bed 20. A wheelhead drive is shown at 22. A slideway 24 defines the X-axis movement of the wheelhead and X-axis traverse is achieved by a drive 26. The workpiece 12 may have a flat or profiled surface which is to be ground by wheel 10.

The drive 22 is carried by a two part support 28, 30 the latter being adjustable in height relative to 28 to define the Y-axis. Movement in the Y-axis is achieved by means of drive 32.

The workpiece is secured to and carried by workpiece tooling 33 carried by a platform 34 which is slidable along a slideway 36 which defines the Z-axis. Movement along the Z-axis is achieved by a Z-axis drive 38.

The nozzle 14 comprises is carried by a Z-axis support 40 which includes a drive motor 42 for positioning the nozzle 14 at the required height and a motor 44 for moving the nozzle

parallel to the X-axis of the machine, so that the nozzle can be positioned close to the point of contact between wheel and workpiece, and by operating the drives 42, 44 as required, can follow the movement of the wheel relative to the workpiece. The upright part of the two-part support 40 is secured to the Z-axis platform 34 by a bracket 46.

An insulated pressure vessel 48 contains liquid nitrogen and can be topped up via an inlet 56. An insulated flexible supply pipe 52 is secured to the nozzle 14 via the on/off valve 18.

A computer based control system is housed in a cabinet 54 having controls 56 by which it can be adapted to supply power to the drive motors 22, 26, 32, 42 and 44, and to operate the valve 18 to supply liquid nitrogen coolant via nozzle 14 during the surface grinding process, to the grinding wheel/workpiece interface.

Fig 3 shows the invention applied to an edge grinding machine in which a circular disc-like workpiece 58 is mounted for rotation about a vertical axis on a rotary table 60 carried by the platform 34, and rotated by a rotary drive 62. The grinding wheel 10 is now mounted for rotation about another vertical axis and the wheelhead drive 22 is now attached to the vertical face of a modified support part 30.

Drives 26 and 32 operate as before to control X and Y axis movement of the wheel 10.

All other parts are as described with reference to Fig 2, the same reference numerals have been employed and reference is made to the foregoing description of Fig 2 for a description of the other parts of the machine and how it operates, except that instead of grinding the surface of workpiece 12 the wheel 10 now grinds the edge of the circular disc workpiece 58 as the latter rotates in contact with the wheel 10.